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BEFORE THE PUBLIC UTILITIES COMMISSION

OF THE STATE OF CALIFORNIA

Application of Southern California Edison Company (U338E) for Approval of the Results of Its 2013 Local Capacity Requirements Request for Offers for the Moorpark Sub-Area. Assigned Commissioner: Michel P. Florio Assigned ALJ: Regina M. DeAngelis	Application 14-11-016 (Filed November 26, 2014)

TESTIMONY OF DAVID CANNON
ON BEHALF OF THE CITY OF OXNARD

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Date: April 8, 2015

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TESTIMONY OF DAVID CANNON
ON BEHALF OF THE CITY OF OXNARD

Please state your name, place of employment, and business address.

My name is David Cannon. I am the President of Everest International Consultants, which is located at 444 West Ocean Boulevard, Suite 1104, Long Beach, CA 90802.

What is the purpose of this testimony?

Southern California Edison has selected an NRG proposal for a new 262 megawatt gas fired generating station ("Project") as part of this RFO proceeding. This testimony assesses potential inundation of the Project site from future tsunami events that could impact the California coast near the City of Oxnard. It also discusses the importance of continuing existing levels of sediment supply for reducing potential tsunami and other coastal hazards, and the uncertainties regarding future sediment supply for the Oxnard coast.

Please describe your qualifications for providing this testimony.

I am a registered Professional Engineer (Civil) with the State of California and I have over 26 years of professional experience in coastal study and design projects. I manage and direct coastal engineering, shore protection, hydraulics, and wetland restoration projects, and have experience with residential shore protection, shoreline preservation (beach building), and pier design. I also have extensive experience studying coastal sediment supply and transport along the California coast. I have attached as Exhibit CO-1 a copy of my resume that includes a selection of my relevant professional experience.

Please describe your evaluation of potential tsunami impacts to the Project site and summarize your findings.

As part of this testimony, I prepared a report that evaluates the threat that tsunami events could pose to the Project site. The report discusses different impacts from tsunamis triggered by local and distant sources. The report also considers how sea level rise would increase the likelihood of inundation from a tsunami event. I have included this report in my testimony as Exhibit CO-2.

The report finds that the Project site would be exposed to impacts from a potential local-source tsunami event like the Goleta 2 landslide scenario. The report also shows that a distant source tsunami, like the 2011 Japanese Tsunami, would impact portions of the Project site under future sea level rise conditions.

How does coastal sediment supply influence protection of the Project site from tsunamis and other coastal hazards?

The beaches and dunes bordering the Project site receive sediment that migrates from north to south along the coast. The two primary sources of sediment are ongoing dredging practices around Ventura Harbor and, to a lesser extent, flooding of the Santa Clara River. For the Ventura Harbor dredging, the U.S. Army Corps of Engineers removes sand that is trapped on the northern side of the harbor and pumps it down the coast towards Oxnard.

If the supply of sediment from these sources is reduced, it would likely decrease the width of the beach and the height of the dunes bordering the Project site. The existing dunes are the site's primary protection from potential coastal impacts. Consequently, a reduced dune height would greatly increase the Project site's exposure to potential tsunami inundation and other coastal hazards.

Are these harbor dredging processes guaranteed to continue?

No, there is uncertainty surrounding the future of dredging and associated sand bypassing activities at Ventura Harbor. The U.S. Army Corps of Engineer's budget for nationwide dredging operations has faced significant shortfalls in recent years. Additionally, Congress must appropriate this dredging funding annually. As a result, dredging activities at Ventura Harbor have decreased in recent years and dredging activities in the future are not guaranteed.

Aside from the information contained in Exhibit CO-2, does this conclude your opening testimony?

Yes.

Exhibit CO-1: Resume of David Cannon

Exhibit CO-2: Sea Level Rise Vulnerability Assessment: Tsunami Analysis Mandalay Bay Generating Station

672020.1

Exhibit CO-1

DAVID **G. C**ANNON, ***P**RESIDENT/**P**RINCIPAL **E**NGINEER*

EDUCATION

Master of Civil Engineering – University of Delaware, Newark, Delaware, 1990
Bachelor of Civil Engineering – University of Delaware, Newark, Delaware, 1986

REGISTRATION

Registered Professional Engineer (Civil), California, #C47116

EXPERIENCE SUMMARY

Mr. Cannon has over 26 years of professional experience with coastal study and design projects. His primary area of interest has been in the field of wetlands restoration planning and design, with additional experience in shoreline preservation and coastal sedimentation. Mr. Cannon manages and directs coastal engineering, shore protection, hydraulics, and wetland restoration projects. His experience also includes projects involving marina planning, residential shore protection, navigation channel and river slope protection, shoreline preservation (beach building), and pier design.

Mr. Cannon has extensive experience in the planning and design of wetland restoration projects. To successfully complete these types of projects, Mr. Cannon has undertaken and/or supervised tidal hydraulic modeling studies, flood control investigations, grading plan development, and cost estimate preparation. He has managed multidisciplinary project teams involving civil engineers, geologists, coastal engineers, biologists, geotechnical engineers, archaeologists, urban planners, permit specialists, and structural engineers to the successful completion of biological and physical project goals.

EXPERIENCE

San Diego South Bay Western Salt Pond Restoration, Imperial Beach, California

Project Engineer under contract to the Southwest Wetlands Interpretative Association (SWIA) for restoration of the Western Salt Ponds (Ponds 10, 10a, and 11) located within the South San Diego Bay Unit of the San Diego National Wildlife Refuge. Mr. Cannon was responsible for leading all engineering aspects of the preliminary design, final engineering design, and construction support of this 200+ acre restoration/dredging project. The project involved the characterization and subsequent dredging of 150,000 cubic yards of material and subsequent disposal within waters of the U.S. as well as coordination of disposal of an additional 60,000 cubic yards of material coming from another project within the area. Mr. Cannon assisted with the development of the sediment Sampling and Analysis Plan (SAP) and subsequent agency approval of the SAP. He was responsible for overseeing the preparation of construction drawings and specifications for all project components including the tide gate structure, earthwork/dredging, and siphon demolition as well as emergency sand bag construction and demolition. In addition, he was responsible for the preparation of construction quantities and cost estimates. Mr. Cannon assisted SWIA with construction bid document development, construction bid review, and contractor selection. During construction, Mr. Cannon assisted the construction manager in verifying that construction activities were being conducted in accordance with the design drawings, including the verification of pay quantities and amounts based on bathymetric surveys and site observations. David was responsible for client interaction, agency presentations, project planning, staff management, budget preparation and control, and schedule monitoring during all phases of this project.

Otay River Estuary Restoration Project, San Diego Bay, California. Project Engineer assisting Poseidon Water LLC and USFWS with restoration of the Otay River Floodplain (ORF) Site (80 acres) and Salt Pond 15 (85 acres), two non-contiguous sites located within the South San Diego Bay Unit of the San Diego Bay National Wildlife Refuge. The project involves excavation of a portion of ORF and placement of excavated material in Salt Pond 15 to create subtidal, intertidal mudflat, intertidal coastal salt marsh, and upland habitats. Mr. Cannon has provided engineering and planning expertise to support alternative development, including the co-development of a soil sampling and analysis program to characterize soils to be excavated from the project for the purpose of determining beneficial reuse and disposal options. He has been overseeing a fluvial hydraulic analysis aimed at evaluating project-induced impacts to flooding and soil erosion/sedimentation. In addition, Mr. Cannon has led the development of construction methods and associated preliminary construction cost estimates for this 160-acre project.

Channel Islands Harbor Circulation Improvement Study, Oxnard, California
Project Manager for a study being conducted for the Ventura County Harbor District to develop circulation improvement alternatives aimed at improving the water quality within Channel Islands Harbor to meet AB411 indicator bacteria criteria. Responsible for managing a multidisciplinary team consisting of hydrologists, hydraulic engineers, marine biologists, civil engineers, and toxicologists from Battelle Memorial Institute and the University of California, Irvine. Mr. Cannon oversaw a numerical modeling analysis of the harbor using the RMA2 and RMA4 components of the Surface Water Modeling System (SMS) developed by Brigham Young University and the U.S. Army Corps of Engineers Waterways Experiment Station. The numerical model was used to simulate the harbor hydraulics (RMA-2) and contaminant dispersal (RMA-4) under existing conditions and to evaluate the effectiveness of circulation improvement alternatives (e.g., pumping) at reducing the number of beach closures for two local recreational beaches (Kiddie Beach and Hobie Beach) associated with indicator bacteria levels that exceed the AB411 criteria. A field program consisting of water velocity, bacteria level, and dye tracking measurements was conducted to develop linkages between circulation and bacteria transport.

San Elijo Lagoon Railroad Double Track Project, San Diego County, California
Study Manager for the coastal and fluvial hydraulic engineering analyses for use by the prime consultant (HDR) in developing bridge designs for the replacement and expansion of the existing railroad bridge that runs across the San Elijo Lagoon in the City of Encinitas. During the design phase of the double-tracked railroad bridge, the San Elijo Lagoon restoration project is simultaneously being developed by others. The study therefore includes scenarios that consider the proposed bridge conditions as well as with and without proposed lagoon conditions. A 2-D model, TUFLOW, was chosen to model the dynamic conditions of the flow in this tidally influenced multi-directional flow lagoon. Model results were then processed and used in the scour and erosion protection analyses and design for the proposed railroad bridge and the tidal inlet channel downstream of the proposed bridge. Mr. Cannon coordinates with other members of the project team and the Lagoon restoration design team, as well as directs the preparation of engineering and environmental technical reports to support the development and submission to SANDAG of the 60%, 90% 100% and Bid ready plans, specifications and

cost estimates. In addition, Mr. Cannon helped identify and develop the appropriate base water elevations to use for assessing the impact of future rises in mean sea level on the flood and inlet channel modeling.

Orange County Coastal Regional Sediment Management Plan, California. Project Manager for the Coastal Sediment Management Plan for Orange County (the Plan). This Plan was created to provide sufficient information for decision makers to develop policies and/or execute management sub-plans to restore and preserve the future vitality of Orange County beaches and coastal areas. Specifically, the Plan includes a comprehensive approach for the conservation, restoration, and preservation of the valuable sediment resources throughout the coastal sedimentsheds of Orange County. The Plan was developed in cooperation with multiple stakeholder groups including the California Coastal Sediment Management Workgroup (co-chaired by the US Army Corps of Engineers and the California Natural Resources Agency), the County of Orange, scientists, planners, elected and appointed officials, and non-government organizations. The Plan addresses coastal maintenance needs through a multi-pronged approach ranging across geographic regions and utilizing many methods ranging from studies, policy changes, construction projects, and development of a joint powers authority. The project purposes, goals, process, data sources, physical, biological, economical, and regulatory aspects, as well as Plan activities and recommendations were summarized in a report and various public presentations.

Del Mar Bluffs Stabilization, Preserving Track Bed Support, Del Mar, San Diego County, California

Coastal Engineer for a project to stabilize the bluffs that provide track bed support for the portion of the coastal rail corridor that runs through the City of Del Mar in San Diego County, California. David was primarily responsible for issues related to coastal processes and coastal engineering. David reviewed the initial set of conceptual bluff stabilization methods to provide coastal engineering input in terms of issues that would need to be addressed during subsequent phases of the project., which included input regarding the need to develop design ocean water levels and wave loads for the seawall alternative as well as the information that would be needed to design the beach nourishment alternative. David was able to develop the necessary rationale to eliminate the seawall and beach nourishment options from further consideration allowing the team to focus their efforts on more promising options. The initial type selection report prepared for the project by other team members was not written in a clear and concise manner and this resulted in delays during negotiations with the City of Del Mar staff. To address this issue, NCTD/SANDAG staff directed SWE to have David reorganize the type selection report and to rewrite portions of the document while editing other portions. In addition, David led the development of an alternative analysis and evaluation process that was used to rank the various stabilization methods in the type selection report. The result of this effort was a report that, after subsequent input from NCTD/SANDAG, was effective in communicating the methods, results, conclusions, and recommendations of the type selection process, thereby allowing the project to move forward. David attended key meetings with the City of Del Mar during the alternative development process to present information and discuss issues related to the coastal processes and coastal engineering aspects of the project, including the consistency of the project with the City's beach preservation ordinance. David was able to complete the work required to advance the project well within the initial budget (approx. $100,000) established for the work through adaptive management and interpretation of the scope such that, in the end, only $28,000 had to be expended to complete the work necessary to advance the project. Upon completion of David's work the project moved forward to final design and construction.

San Dieguito River Bridge Hydraulic Analysis, San Diego County, California
Study Manager for a hydraulic analysis of the San Dieguito River conducted for the North County Transit District (NCTD) to analyze flood elevations and velocities for use by the prime consultant (David Evans and Associates) in developing bridge designs for the replacement of the existing railroad bridge that runs across the San Dieguito River in Del Mar. The analysis was conducted with the unsteady flow version of the hydraulic flow model known as HEC-RAS, which is a fluvial processes model approved for use by the Federal Emergency Management Agency (FEMA). The unsteady flow version was chosen to more accurately model the dynamic conditions of the river in this location since river flows and tidal flows are comingled in this portion of the river channel. In addition, David helped identify and develop the appropriate base water elevations to use for assessing the impact of future rises in mean sea level on the flood modeling.

Encinitas & Solana Beach Shoreline Protection EIS/EIR, San Diego County, California
Coastal Engineer responsible for assisting the U.S. Army Corps of Engineers, Los Angeles District with the preparation of a joint EIS/EIR for the Encinitas & Solana Beach Shoreline Protection. Everest is serving as the prime consultant with Anchor Environmental (Anchor), Chambers Group (Chambers), and Science Applications International Corporation (SAIC) providing services as subconsultants. Mr. Cannon is responsible for evaluating impacts to oceanographic and coastal processes and for working with the project biologist (Karen Green – SAIC) to analyze impacts to nearshore habitat (kelp, reef, and surfgrass). In this role, Mr. Cannon is responsible for the shoreline morphology analyses necessary to support the preliminary engineering design, economic analysis, and nearshore habitat impact assessment. The nearshore habitat impact methodology, which was developed jointly by SAIC and Everest, is based on the methodology utilized successfully to obtain environmental approvals for the SANDAG Regional Beach Sand Project in 2000.

Buena Vista Lagoon Restoration Feasibility Study, Carlsbad, California
Project Manager for a study aimed at determining the feasibility of restoring the 220-acre Buena Vista Lagoon, which is located at the border of Oceanside and Carlsbad in San Diego County. Mr. Cannon was responsible for managing a multidisciplinary team of hydrologists, biologists, ecologists, engineers, and regulatory specialists as well as coordinating study activities with a Technical Advisory Committee. The existing lagoon is a fresh water hydrologic regime that provides habitat for fresh water fish and invertebrates, migratory birds, and waterfowl, including several threatened and/or endangered species. The study involved development of restoration goals/objectives, characterization of existing conditions (wildlife surveys, vegetation surveys, habitat mapping, dredged material characterization, and upstream watershed assessment), identification of restoration opportunities/constraints, development of restoration alternatives, evaluation of restoration alternatives, agency coordination, and public

involvement. A unique aspect of the study was the need to help decision makers determine the hydrologic regime that the Lagoon should be maintained under in the future and the Study Team developed a unique analysis and alternative development approach to address this unique aspect of the study. In addition to his role in managing the multidisciplinary study team, Mr. Cannon was also responsible for developing the content of public workshops and for presenting the material to agency representatives and members of the interested public.

Huntington Beach Bluff Top Park Storm Damage Reduction Feasibility Study, Huntington Beach, California

Study Manager for a feasibility study (F3 milestone) to establish baseline, without project conditions for the Huntington Beach Bluff Top Park in Huntington Beach, California. The study involved identifying existing conditions, analyzing historical aerial photographs (shoreline and bluff top position), estimating future bluff top erosion, conducting economic analyses, and preparing three reports (Aerial Photograph and Shoreline Mapping Appendix, Coastal Engineering Appendix, and F3 Main Report). A unique aspect of this project was the use of a risk-based method to analyze storm damage costs and benefits. The methodology was based on the use of a Monte Carlo model that linked extreme bluff top erosion events to economic damages over a 50-year simulation period. The bluff top erosion event information was developed by relating historical bluff erosion to storm wave energy to arrive at erosion values for a given return period (e.g., 50-year erosion value). Since a portion of the bluff top is armored with concrete rubble, separate erosion events were developed for the armored and unarmored areas (a.k.a., non-embayment and embayment). David was responsible for managing all aspects of the feasibility study, overseeing the economics analysis conducted by David Miller & Associates, and presenting the study methods and results at meetings with the local sponsor (City of Huntington Beach). He also wrote and/or edited the Aerial Photograph and Shoreline Mapping Appendix, Coastal Engineering Appendix, and F3 Main Report.

Agua Hedionda Lagoon Northern Jetty Restoration, Carlsbad, California

Project Engineer for restoration of a 200-foot long section of the northern inlet jetty along Agua Hedionda Lagoon in the City of Carlsbad, California. The project involved preliminary engineering design, environmental review, permitting, and final design. Mr. Cannon was responsible for directing all of the study components related to engineering. This included design wave analysis, stone size selection, cross-section design, construction method development, and cost estimate preparation. In addition, the one-line numerical model known as GENESIS, was utilized to perform a shoreline impact assessment. The assessment was used to estimate the potential impacts of the project on adjacent shorelines (i.e., erosion and accretion) and to develop mitigation measures (e.g., initial beach fill) aimed at reducing the potential impacts to levels considered insignificant. Mr. Cannon was responsible for presenting the engineering and coastal processes components of the project studies to the regulatory agencies (e.g., USACE, SLC, and CCC), local government entities (e.g., City of Carlsbad), resource agencies (e.g., USFWS, NMFS, and CDFG), and environmental action groups (e.g., Agua Hedionda Lagoon Foundation).

Orote Point Landfill Revetment, Guam, U.S. Trust Territory

Project Manager for a shore protection design project on the Island of Guam. Management responsibilities included project planning, client interaction, budget control, and schedule management. Technical elements included wave runup analyses using numerical and physical models, as well as seawall and revetment alternative development and evaluation. Stringent design criteria had to be developed since the purpose of the shore protection device was to maintain the integrity of a landfill containing contaminated and hazardous material that was located adjacent to a marine preserve. An engineering cost analysis of the various alternatives was performed to determine the most cost-effective solution for implementation by the U.S. Navy. A revetment composed of concrete armor units (cubes) and stone underlayer was selected for design. Mr. Cannon was responsible for the preparation of the engineering plans and specifications that were ultimately included in the bid document package.

Batiquitos Lagoon Enhancement Project, Carlsbad, California

Coastal Engineer for a physical model study of cobble transport associated with the Batiquitos Lagoon Enhancement Project. Mr. Cannon was responsible for evaluating the dynamics of the Batiquitos Lagoon cobble beach in Carlsbad, California. The purpose of this study was to determine the effectiveness of shore-perpendicular jetties at reducing cobble infilling of a proposed tidal inlet. The study results were also used to estimate bridge soffit elevations by providing additional information regarding the design water elevation.

Marina Del Rey Dredged Material Management Plan Development, Marina Del Rey, California

Mr. Cannon served as project manager for the technical studies used by the U.S. Army Corps of Engineers to develop a Dredged Material Management Plan for Marina Del Rey, California. Mr. Cannon was responsible for client interaction, scope development, staff management, schedule performance, and budget control. He authored the technical feasibility report that was used to develop the F-4 planning report by the USACE project manager. Coastal engineering elements of the project included alternative plan development, sediment budget development, river sedimentation estimation, two-dimensional tidal hydraulic modeling (SMS with RMA-2), two-dimensional transport modeling of heavy metals (SMS with RMA-4), shoaling rate calculation, dredged material disposal alternatives analysis (e.g., confined aquatic disposal, upland placement, offshore disposal, confined upland disposal), construction method development, and cost estimate preparation. When Mr. Cannon took control of this four-month project it was in the third month and only 35 percent of the work tasks were complete. Under his leadership, the draft report was completed on the scheduled due date, just over one month from the time he became the designated project manager. Coordinating and managing staff to meet this schedule was complicated by the fact that the final due date was in early January just after the holiday season.

Lomas Santa Fe Drive Grade Separation, Solana Beach, California

Project Manager and Coastal Engineer for design of the beach disposal component of the Lomas Santa Fe Grade Separation Project in Solana Beach, California. This project involved physical and chemical sediment sampling, testing, and analysis to determine beach disposal compatibility. Since the regulatory agencies did not have sediment sampling, testing, and analysis guidelines for beneficial use of terrestrial material at the time, the project required extensive coordination between the client, regulatory/resource agencies, and project team members. Mr. Cannon was responsible for scheduling and facilitating project team meetings, keeping all constituencies informed of progress, and managing action items to completion. Additional project management responsibilities included agency coordination, budget control, schedule maintenance, client interaction, and regulatory agency and City Council (City of Solana Beach) presentations. Developed a sediment sampling and analysis plan (SAP) and coordinated with resource and regulatory agency personnel to gain SAP approval. Coastal engineering responsibilities included physical analysis of sediment quality data (e.g., grain size, contaminant concentrations), conceptual sand placement plans, permit preparation, and preparation of engineering plans, specifications, and construction cost estimates. Mr. Cannon was also responsible for conducting site observations during construction to make sure that the project was constructed in substantial accordance with the design. This proved very cost effective as Mr. Cannon was able to get the U.S. Army Corps of Engineers to reduce the level of monitoring from two locations (sediment source and receiver site) to one location, thereby lowering construction monitoring costs.

Santa Barbara Harbor Dredging Management Feasibility Study, Santa Barbara, California
Coastal Engineer for an alternative dredging program study of Santa Barbara Harbor. Performed a littoral transport study, which involved analysis of wave climate including island sheltering, angular spreading, refraction, and shoaling.

Flood Protection Feasibility Study, Seal Beach, California
Coastal Engineer of a flood protection feasibility study conducted for the City of Seal Beach. Assisted in the development of conceptual alternatives including a manmade reef to reduce coastal flooding of private residences due to concurrent high tides and waves. Evaluation of alternatives was based on wave runup reduction, maintenance requirements, constructability, and economic considerations.

Small Craft Marina Design, Commencement Bay, Port of Tacoma, Washington
Project Engineer for a 200-boat small craft marina located within Commencement Bay near the Port of Tacoma. Oceanographic design criteria including winds, water levels, and waves were developed and used to estimate the wind and wave loads on the dock system.

Pebbly Beach Small Craft Marina Feasibility Study, Avalon, California
Coastal Engineer for the feasibility study of a small craft marina located in the vicinity of Pebbly Beach on Catalina Island. The project involved the development of wave reduction structure concepts and preparation of associated cost estimates.

Shore Protection Structures, Ebeye, Marshall Islands
Coastal Engineer for the design and analysis of shore protection structures to protect a causeway from wave action in the North Pacific. The study included wave climate analyses, wave runup and overtopping analyses, water level analyses, shore protection design, and cost estimate preparation. An innovative feature of this project was the design and construction of a dynamically stable revetment for shore protection.

Santa Monica Breakwater Restoration Feasibility Study, Santa Monica, California
Project Engineer for an economic storm damage assessment study of the Santa Monica Pier conducted for the U.S. Army Corps of Engineers. Responsibilities included client interaction, budget tracking, and cost estimate preparation. Also assisted in the development of an economic model to estimate storm damage to the pier and assign costs to those damages.

Waterfront Development Feasibility Study, Island of Molokai, Hawaii
Project Engineer for a proposed 125-acre waterfront development project along the west coast of Molokai. Responsibilities included conducting wave transformation studies, developing marina concepts, performing boat distribution analyses, and preparing cost estimates.

Marina Development Feasibility Study, Kohanaiki, Island of Hawaii, Hawaii
Project Engineer involved in the development of alternative concepts for a proposed marina on the west coast of Hawaii. Prepared cost estimates and assisted in basin layout and boat distribution, as well as, analysis of wave-induced basin oscillations.

Small Craft Marina and Residential Development Feasibility Study, La Salina, Baja Mexico
Coastal Engineer for a proposed small-craft marina and residential development located along the Pacific Coast in Baja Mexico between Tijuana and Ensenada. Responsibilities included determination of wave climate, design water levels, and design wave conditions for use in developing preliminary ocean entrance configurations and designing the corresponding ocean entrance structures.

San Malo Shoreline Protection Device Design, Oceanside, California
Coastal Engineer involved in the design of a stone revetment to protect the San Malo Residential Complex in Oceanside, California from ocean waves and inundation. Analyses included determination of water level statistics, design wave conditions, wave runup, wave overtopping, and stable revetment structure.

Coastal Flood Water Elevation Study. Huntington Beach, California
Coastal Engineer responsible for determining ocean water levels in the Talbert Channel during the January and March 1983 storms. These water levels were used in a backwater analysis of the Talbert Channel to determine areas of channel overflow. Analyses included determination of extreme waves, storm surge, pressure and astronomical tides, and wave setup, as well as conducting wave transformation.

PUBLICATIONS AND PRESENTATIONS

Cannon, D. *"Orange County Coastal Regional Sediment Management Plan"*, presented at American Shore and Beach Preservation Association (ASBPA)'s 2012 National Coastal Conference: "Rising to the Challenge", San Diego, October 9-12, 2012.

Cannon, D., Y. Poon, and S. Innes *"SANDAG Regional Beach Sand Project II: Shoreline and Profile Modeling",* presented at American Shore and Beach Preservation

Association (ASBPA)'s 2011 National Coastal Conference: "Expanding Coastal Horizons", New Orleans, October 18-21, 2011.

Cannon, D. *"Project Incorporation of Global Mean Sea Level Rise",* presented at Port of San Diego Tenants Association, August 29, 2011.

Cannon, D. *"Dredging, Filling, and Breaching Solar Salt Ponds to Restore Tidal Salt Marsh in San Diego Bay"*, presented at Headwaters to Oceans (H2O) Conference, San Diego, May 23-26, 2011.

Cannon, D. *"Incorporation of Sea Level Rise into Local, State, and Federal Projects"*, presented at San Diego Association of Governments (SANDAG) Shoreline Preservation Working Group (SPWG) Meeting, San Diego, December 3, 2009.

Cannon, D. *"Considering Sea Level From Science To Guidelines To Project Definition",* presented at Headwaters to Oceans (H2O) Conference, Long Beach, October 27-29, 2009.

Cannon, D. *"Beach Restoration Regulatory Guide",* presented at Headwaters to Oceans (H2O) Conference, Long Beach, October 24-26, 2007.

Cannon, D., D. Davenport, and J. Gurish *"Sediment Master Plan Policies, Procedures, and Regulations (PPR) Analysis",* presented at California and the World Ocean (CWO) Conference, Long Beach, September 17-20, 2006.

Cannon, D., "*Sediment Management - Policies, Procedures and Regulations,*" presented at Headwaters to Oceans (H2O) Conference, Huntington Beach, California, October 26-28, 2005.

Nathan, R., D. Cannon, "*Articulating Block Mat Revetment For Whaler's Village*", presented at the ASCE Coastal Engineering Practice '92 Conference and published in the proceedings, 1992.

672021.1

Exhibit CO-2

Sea Level Rise Vulnerability Assessment: Tsunami Analysis
Mandalay Bay Generating Station

Final Report

Prepared For:

City of Oxnard
214 South C Street
Oxnard, California 93030

Contact: Chris Williamson, AICP

Prepared By:

Everest International Consultants, Inc.
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Long Beach, California 90802

Contact: David Cannon, M.C.E., P.E.

April 8, 2015

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1. PURPOSE AND OBJECTIVES

The purpose of the analysis presented in this report is to determine the degree of potential inundation at the Mandalay Bay Generating Station (MBGS) site associated with tsunamis both without and with sea level rise. The following objectives were established to fulfill the purpose:

- Select tide condition
- Select future sea level rise conditions
- Select tsunami events
- Determine the extent of potential tsunami-induced inundation

2. APPROACH

Potential tsunami Inundation elevations were determined based on selected tide elevations and tsunami wave heights. These potential tsunami inundation elevations were then mapped at the generating station site using GIS and topographic/bathymetric data to evaluate areas with the potential to be inundated by a tsunami occurring in Year 2015 without sea level rise consideration and a tsunami occurring in Years 2030, 2060, and 2100 with sea level rise consideration.

3. FLOOD ELEVATIONS

3.1 TIDES

Tide levels are monitored by the National Oceanic and Atmospheric Administration (NOAA) along the California coastline at designated tide stations. The Santa Barbara station (Station 9411340) and Santa Monica station (Station 9410840) are the two NOAA stations closest to the generating station. Tidal datums obtained from NOAA for these two stations are shown in Table 1 with elevations in feet relative to the North American Vertical Datum of 1988 (NAVD88). These tidal datums represent long term average water levels for the latest National Tidal Datum Epoch from Years 1983 to 2001. Since the generating facility is approximately equal distance from these two NOAA stations, the average tide elevation at the two tide stations was used for this analysis. For the tsunami potential inundation analysis, Mean Higher High Water (MHHW) was selected as the tide condition for the historical tsunami (2011 Japanese Tsunami) while Mean Sea Level (MSL) was selected as the tide condition for the local source generated tsunami.

Table 1. NOAA Tidal Datums for Santa Barbara and Santa Monica

TIDE	ELEVATION (FEET, NAVD88)	
	SANTA BARBARA (STATION 9411340)	SANTA MONICA (STATION 9410840)
Highest Observed Water Level	7.26	8.31
Mean Higher High Water (MHHW)	5.27	5.24
Mean High Water (MHW)	4.51	4.50
Mean Sea Level (MSL)	2.66	2.60
Mean Low Water (MLW)	0.85	0.74
North American Vertical Datum – 1988 (NAVD88)	0.00	0.00
Mean Lower Low Water (MLLW)	-0.13	-0.19
Lowest Observed Water Level	-3.02	-3.03

3.2 SEA LEVEL RISE

To be consistent with the study conducted by Revell Coastal (2015) on the vulnerability of the generating station to coastal hazards and climate change, the same sea level rise projections for Years 2030, 2060, and 2100 used for that study were used for this analysis to define future mean sea level conditions. These sea level rise projections are provided in Table 2.

3.3 TSUNAMIS

The 2010 Chilean and 2011 Japanese tsunamis were the most significant tsunamis to hit California since the 1964 Alaska tsunami. The 2010 Chilean tsunami was generated by a magnitude 8.8 earthquake on February 26, 2010 at the Maule region near central Chile, and the tsunami subsequently reached the Los Angeles region around noon on February 27, 2010. On March 11, 2011, a magnitude 9.0 earthquake struck the east coast of the Tohoku region in Japan, and it generated a large tsunami that reached the Los Angeles region at around 8:40 am on March 11, 2011.

The NOAA ocean water level data collected at the Santa Barbara and Santa Monica gages for these two tsunami events were downloaded and analyzed for this analysis. Figure 1 shows the marigrams at Santa Monica and Santa Barbara for the 2010 Chilean event. In the figure, the blue line shows the measured ocean water level and the green line shows the predicted ocean water level. The difference between the measured and predicted tide (shown as the red line in the figure) primarily represents the tsunami wave. Based on the data, the maximum measured tsunami amplitude was approximately 1.61 ft at Santa Monica and 1.91 ft at Santa Barbara. Similar plots for the 2011 Japanese tsunami are shown in Figure 2. For this tsunami event, the maximum tsunami amplitude at Santa Monica was about 2.43 ft and 2.39 ft at Santa Barbara. The tsunami wave amplitude off the shoreline of the generating station is likely between those measured at Santa Monica and Santa Barbara so an average value was calculated for these two locations (1.75 ft for the 2010 Chilean event and 2.41 ft for the 2011 Japanese event) to represent the tsunami amplitude. For this analysis, the 2011 Japanese event tsunami amplitude was used since it represented the higher tsunami wave condition.

Given the lack of information for historical tsunami events and potential for extreme tsunami events that have not been captured in the historical record, consideration was given to potential tsunamis that could be generated by distant sources and local sources. The State of California conducted an analysis of tsunamis that could be generated by numerous distant sources (e.g., Cascadian Subduction Zone earthquake) and local sources (e.g., Goleta 2 Landslide). A numerical model was used in the analysis conducted by the State of California to determine the maximum potential tsunami elevation for each individual source and then the maximum tsunami elevation was identified for each source type (distant and local). The results were provided for different locations along the California coast, including the Oxnard area. For the Oxnard area, the maximum tsunami height from the Goleta 2 Landslide source was reported as +10 ft (California Geological Survey, 2014). There was no vertical datum associated with this tsunami height; however, it mentions in the report that the tsunami heights were obtained from the state tsunami hazard mapping conducted in 2009, which were based on a vertical datum of Mean High Water (MHW) so the tsunami elevation is +10 ft, MHW. Since MHW is approximately 2 feet above MSL (see Table 1), the tsunami elevation associated with the Goleta 2 Landslide source is approximately +12 ft, MSL. This tsunami was selected for inclusion in the analysis presented herein to allow consideration of a potentially large tsunami not captured in the historical record that could strike the Oxnard coast in the future. Consistent with the California Geological Survey's tsunami guidance report, the City of Oxnard is using the Goleta 2 Landslide scenario for emergency evacuation and coastal planning purposes.

3.4 POTENTIAL INUNDATION ELEVATIONS

The tsunami potential inundation elevations for the 2011 Japanese tsunami and Goleta 2 Landslide tsunami are summarized in Table 2 and Table 3, respectively. The values in Table 2 are based on the tsunami occurring during a high tide condition of MHHW under Year 2015 current sea level condition and future sea level conditions (i.e., with sea level rise) in Years 2030, 2060, and 2100. The values in Table 3 are based on the tsunami occurring during a tide condition of MSL under Year 2015 current sea level condition and future sea level conditions (i.e., with sea level rise) in Years 2030, 2060, and 2100.

Table 2. 2011 Japanese Tsunami Potential Inundation Elevations

YEAR	MHHW (FT, NAVD88)	TSUNAMI AMPLITUDE (FT)	SEA LEVEL RISE (FT)	INUNDATION ELEVATION (FT, NAVD88)
2015	5.26	2.4	0.00	7.7
2030	5.26	2.4	0.67	8.3
2060	5.26	2.4	2.11	9.8
2100	5.26	2.4	4.84	12.5

Table 3. Goleta 2 Landslide Tsunami Potential Inundation Elevations

YEAR	TSUNAMI NEARSHORE HEIGHT (ELEVATION)		SEA LEVEL RISE (FT)	INUNDATION ELEVATION (FT, NAVD88)
	(FT, MSL)	(FT, NAVD88)		
2015	12.0	14.63	0.00	14.6
2030	12.0	14.63	0.67	15.3
2060	12.0	14.63	2.11	16.7
2100	12.0	14.63	4.84	19.5

4. Data Used in GIS-aided Inundation Analysis

4.1 Imagery: World Imagery

The imagery "World Imagery" is available as a basemap in ESRI ArcGIS (ESRI, 2015). World Imagery provides one meter or better satellite and aerial imagery in many parts of the world and lower resolution satellite imagery worldwide. The map features 0.3 meter (m) resolution imagery in the continental United States.

4.2 Topographic/Bathymetric Data: 2013 NOAA Coastal California TopoBathy Merged Project

The raster data set was downloaded from the NOAA Digital Coast Data Access Viewer (NOAA, 2015). Data providers include the California State Coastal Conservancy, California Ocean Protection Council, and California Department of Water Resources. The data was extracted from a larger classified data set and only includes points classified as Ground, Model Key-point (mass point), Bathymetric Lidar Points, and Acoustic Bathymetry (bare earth) within the requested geographic bounds. This project merged recently collected topographic, bathymetric, and acoustic elevation data along the entire California coastline from approximately the 10 m elevation contour out to the three-mile State water's boundary.

The topographic Lidar data used in this merged project was the 2009-2011 California State Coastal Conservancy Lidar Project. The bathymetric Lidar data used in this merged project was 2009-2010 U.S. Army Corps of Engineers (USACE) Joint Airborne Lidar Bathymetry Center of Expertise (JALBTCX) Lidar, provided by JALBTCX. The data were collected for the California Coastal Mapping Project. The multibeam acoustic data used in this merged project were provided by the California Seafloor Mapping Program, Ocean Protection Council and NOAA's National Geophysical Data Center. Vertical accuracy of the topographic data is reported at 4.8 centimeters (cm) root mean square error (RMSE). JALBTCX bathymetric data is reported at 15 cm RMSE. As multiple multibeam acoustic datasets from multiple sources were used, the vertical accuracy varies. Horizontal accuracy is 100 cm.

5. Tsunami Potential Inundation Areas

Tsunami potential inundation elevations accounting for tide, tsunami wave amplitude/height, and sea level rise for Years 2015, 2030, 2060, and 2100 were superimposed on topographic maps for the area in the vicinity of the generating station to determine the area that may be inundated if there are hydraulic connections between the tsunami wave and low lying areas.

An example of a hydraulic connection would be breaches in the beach dune system that lies between the ocean and generating stations. Such breaches could occur during a tsunami with the initial tsunami waves eroding the beach and breaching the dune system. In addition, such breaches could occur in the future due to gradual erosion of the dune system associated with decreases in sand supply. These reductions would include natural reductions in sand transported to the ocean via rivers (e.g., Santa Clara River) and changes in sand bypassed around Ventura Harbor upcoast from MBGS. Given recent reductions in maintenance bypassing by the U.S. Army Corps of Engineers in the area, the future viability of such activities is uncertain.

5.1 2011 Japanese Tsunami

Tsunami potential inundation maps for the MBGS for Years 2015, 2030, 2060, and 2100 are shown in Figures 3, 4, 5, and 6, respectively. The areas in the vicinity of the MBGS below 7.7 ft, NAVD88 (potential inundation elevation for Year 2015) are shaded blue in Figure 3. As shown in the figure, the MBGS facility is above 7.7 ft, NAVD88; hence, it is unlikely to be inundated during a tsunami event in Year 2015. As shown in Figures 4 and 5, the ground elevations of the MBGS facility are higher than the corresponding potential inundation elevations for Years 2030 and 2060 so these areas are also not likely to be inundated by this tsunami even if a hydraulic connection becomes established between the ocean and this area. In Figure 6, the areas below 12.5 ft, NAVD88 (potential inundation elevation for Year 2100) are shaded blue. A significant portion of the MBGS facility is lower than the potential inundation elevation for Year 2100 so this area has the potential to be inundated by this tsunami if a hydraulic connection becomes established between the ocean and this area. Some of the existing parking area is lower than the Year 2100 inundation elevation, but the access roads leading to/from the MBGS are above 12.5 ft, NAVD88, so this tsunami would not likely impact access to the MBGS facility even under the Year 2100 sea level rise condition.

5.2 Goleta 2 Landslide Tsunami

Tsunami potential inundation maps for the MBGS for Years 2015, 2030, 2060, and 2100 are shown in Figures 7, 8, 9, and 10, respectively. The areas in the vicinity of the MBGS below 14.6 ft, NAVD88 (inundation elevation for Year 2015) are shaded blue in Figure 7. As shown in the figure, most of the MBGS facility is below 14.6 ft, NAVD88; hence, it is likely to be inundated during this tsunami event if it occurred in Year 2015. The amount and extent of inundation is expected to increase in Year 2030, Year 2060, and Year 2100 as sea level increases. Some portions of the access roads leading to/from the MBGS are below 14.6 ft, NAVD88 so it is likely that this tsunami would start to impact access to the MBGS facility if it occurred in Year 2015. The impact to access to/from the MBGS increases in Year 2030, Year 2060, and Year 2100 as sea level rises.

6. Summary

Based on the results of the tsunami potential inundation analysis, the MBGS is not likely to experience substantial inundation by a tsunami similar to the 2011 Japanese tsunami if it occurred in Year 2015 with a hydraulic connection between the ocean and generating station site. Although sea level rise is likely to result in increased potential inundation during this tsunami at the generating station, the effect is not expected to be substantial between Year 2015 and Year 2060. However, by Year 2100 tsunami-induced potential inundation has the potential to impact operations at the site. The year at which impacts to operations would be expected is not known but it would likely occur sometime between Year 2060 and Year 2100.

Based on the results of the tsunami potential inundation analysis, the MBGS is likely to experience substantial inundation by a tsunami generated by the Goleta 2 Landslide if a hydraulic connection is established between the ocean and generating station site. Potential inundation would likely occur in Year 2015 with the amount and extent of potential inundation increasing in the future as sea level increases in accordance with sea level rise projections.

7. References

California Geological Survey, California Governor's Office of Emergency Services, and National Oceanic Atmospheric Administration. 2014. "Tsunami Emergency Response Playbooks and FASTER Tsunami Height Calculation: Background Infomration and Guidance for Use." Funded by the National Tsunami Hazard Mitigation Program. California Geological Survey Special Report 236. November 13, 2104.

ESRI 2015. http://services.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer

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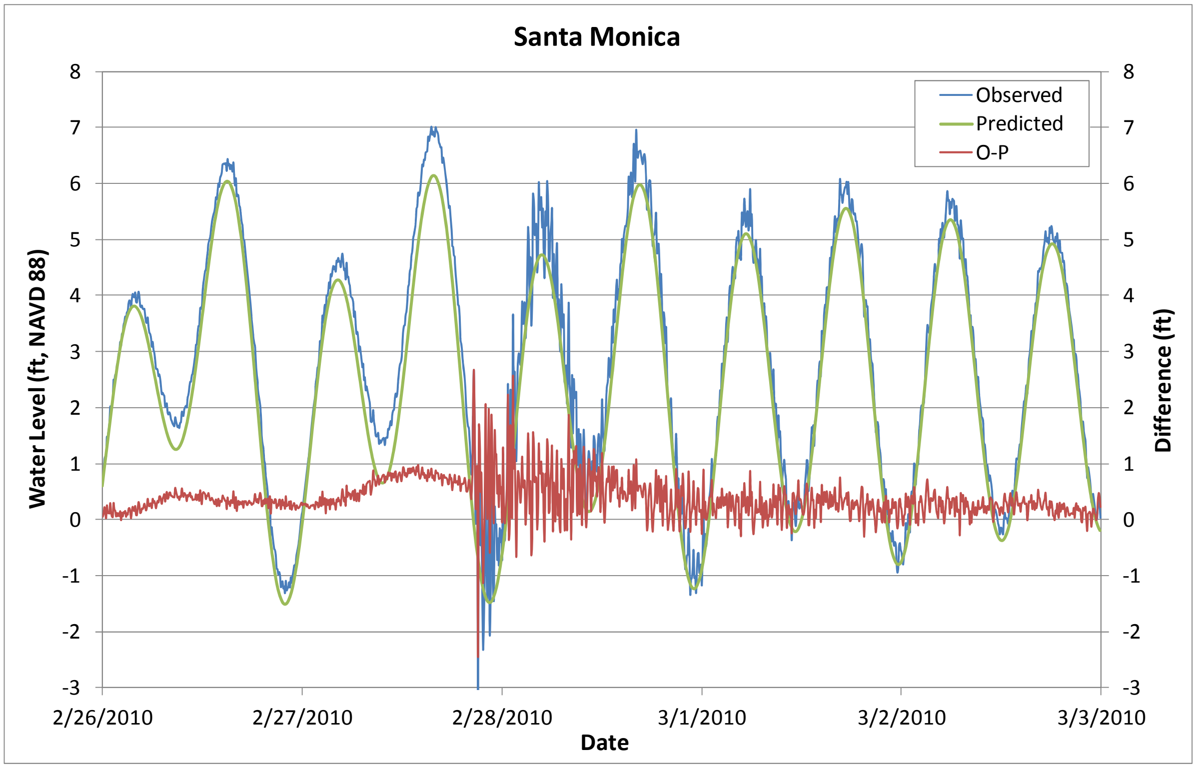
Revell Coastal. 2015. "Vulnerability of Mandalay Generating Station to Existing and Future Coastal Hazards and Sea Level Rise," Prepared for City of Oxnard, April 2015.



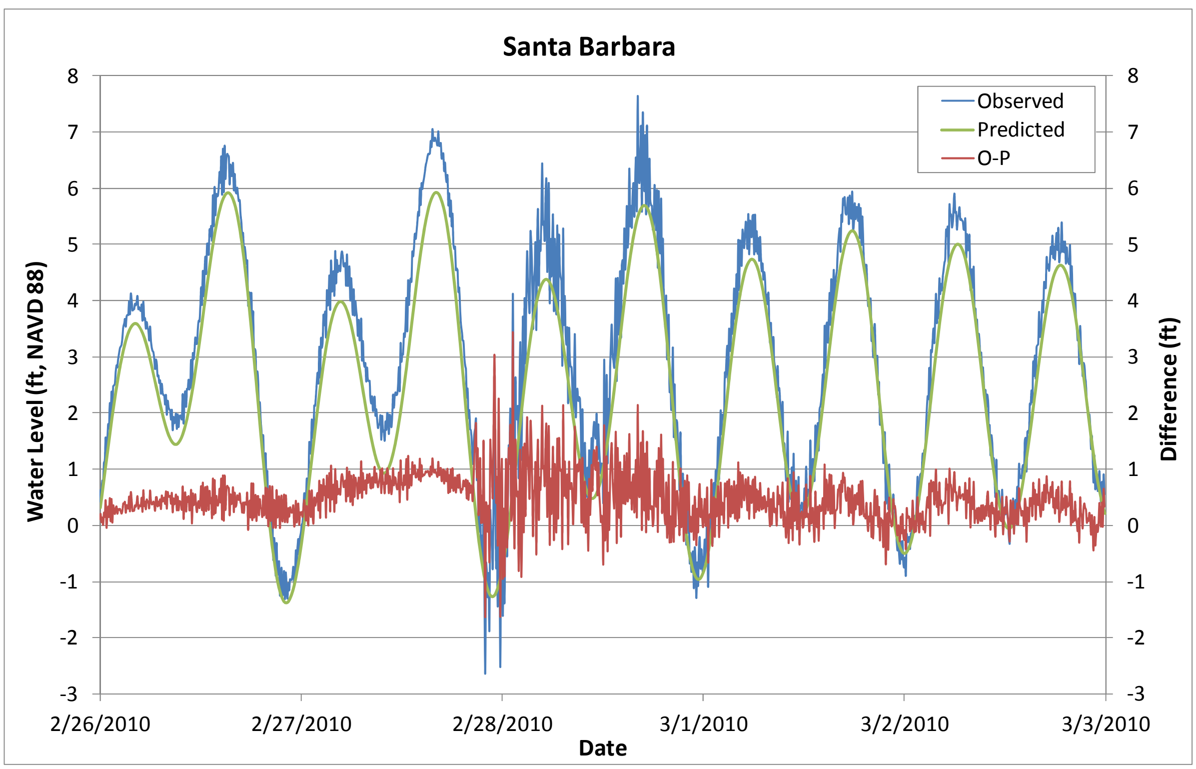
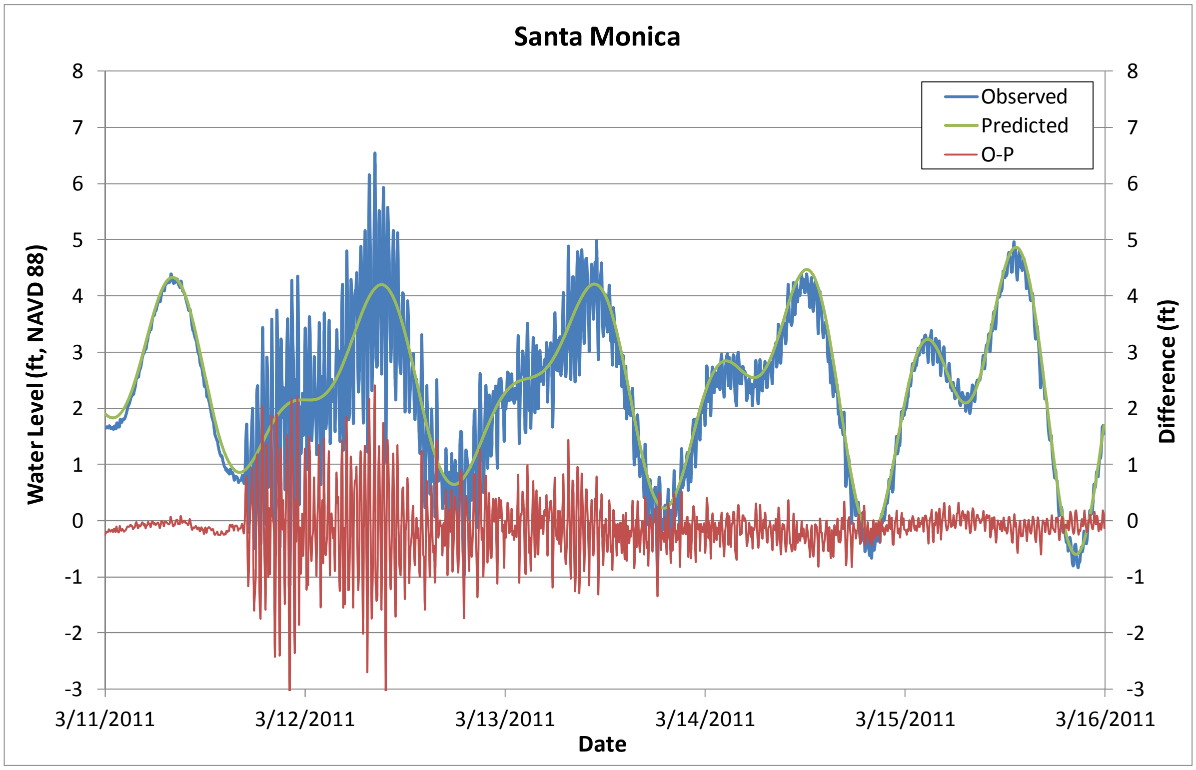


Figure 1. Marigrams for Santa Monica and Santa Barbara during the February 27, 2010 Chilean Tsunami



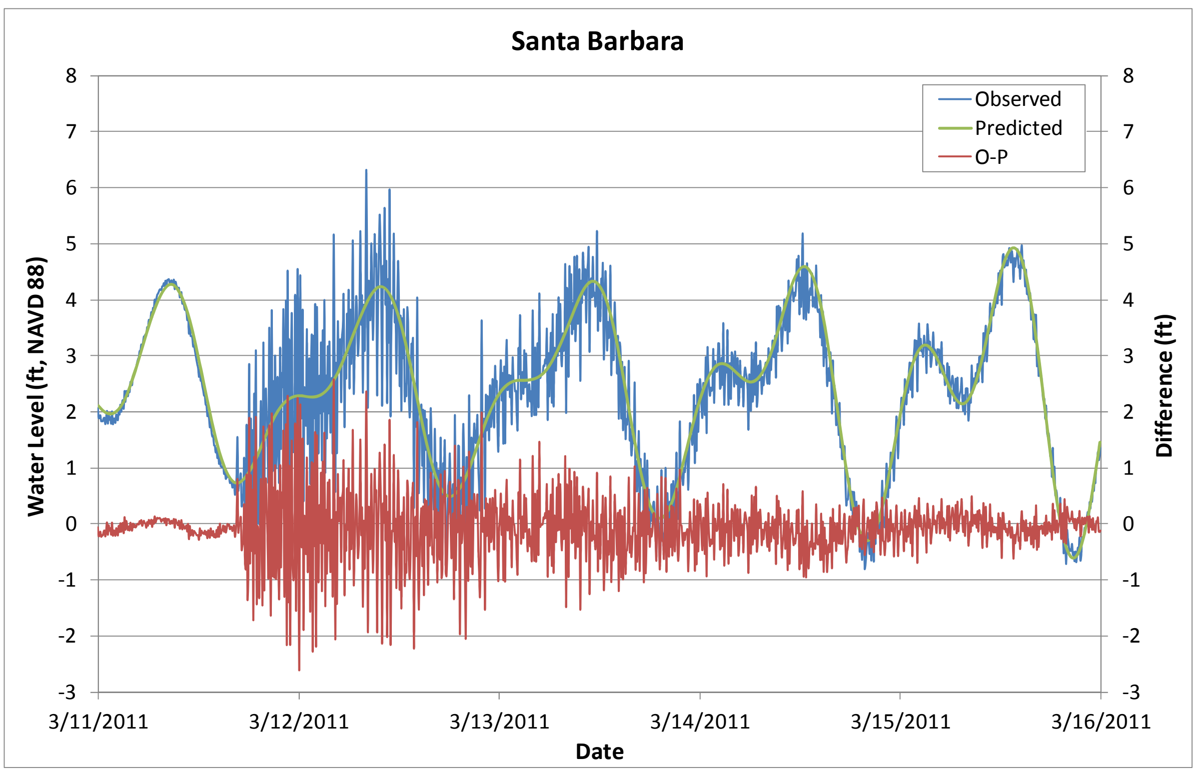
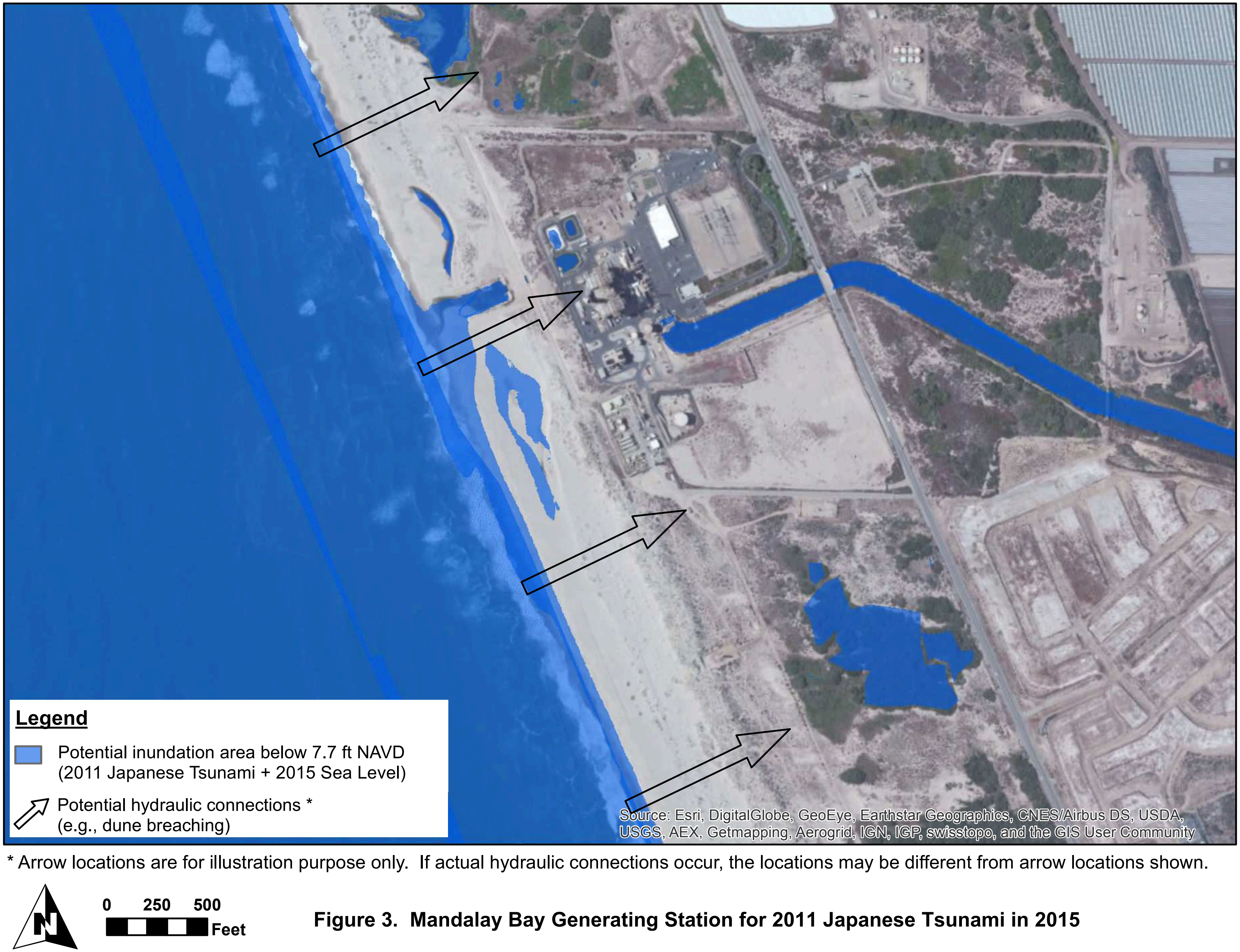


Figure 2. Marigrams for Santa Monica and Santa Barbara during the March 11, 2011 Japanese Tsunami



* Arrow locations are for illustration purpose only. If actual hydraulic connections occur, the locations may be different from arrow locations shown.

Figure 3. Mandalay Bay Generating Station for 2011 Japanese Tsunami in 2015

* Arrow locations are for illustration purpose only. If actual hydraulic connections occur, the locations may be different from arrow locations shown.

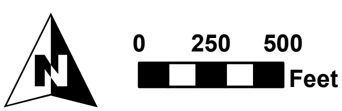


Figure 4. Mandalay Bay Generating Station for 2011 Japanese Tsunami in 2030

* Arrow locations are for illustration purpose only. If actual hydraulic connections occur, the locations may be different from arrow locations shown.

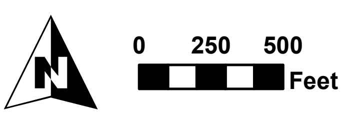


Figure 5. Mandalay Bay Generating Station for 2011 Japanese Tsunami in 2060

* Arrow locations are for illustration purpose only. If actual hydraulic connections occur, the locations may be different from arrow locations shown.

Figure 6. Mandalay Bay Generating Station for 2011 Japanese Tsunami in 2100

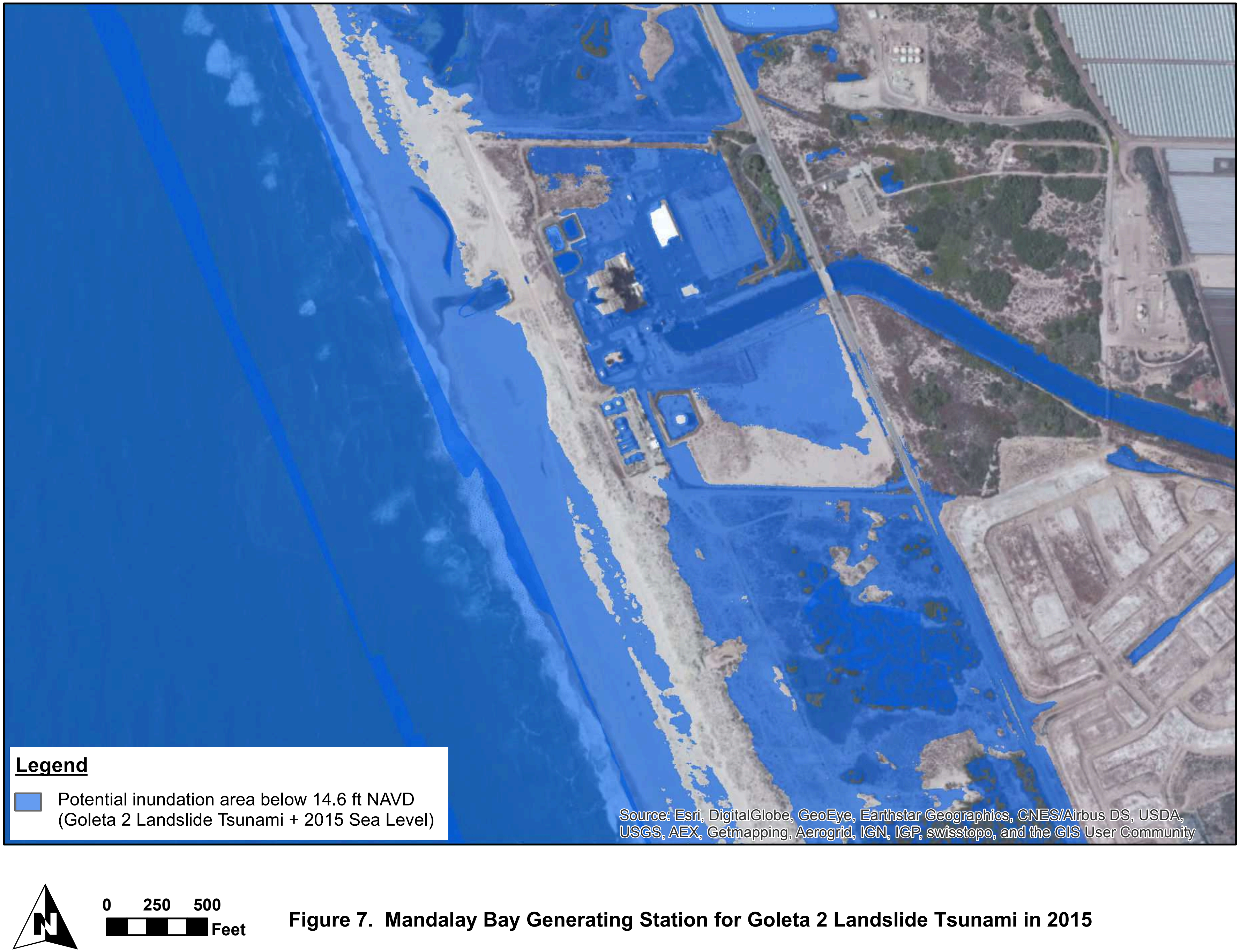


Figure 7. Mandalay Bay Generating Station for Goleta 2 Landslide Tsunami in 2015

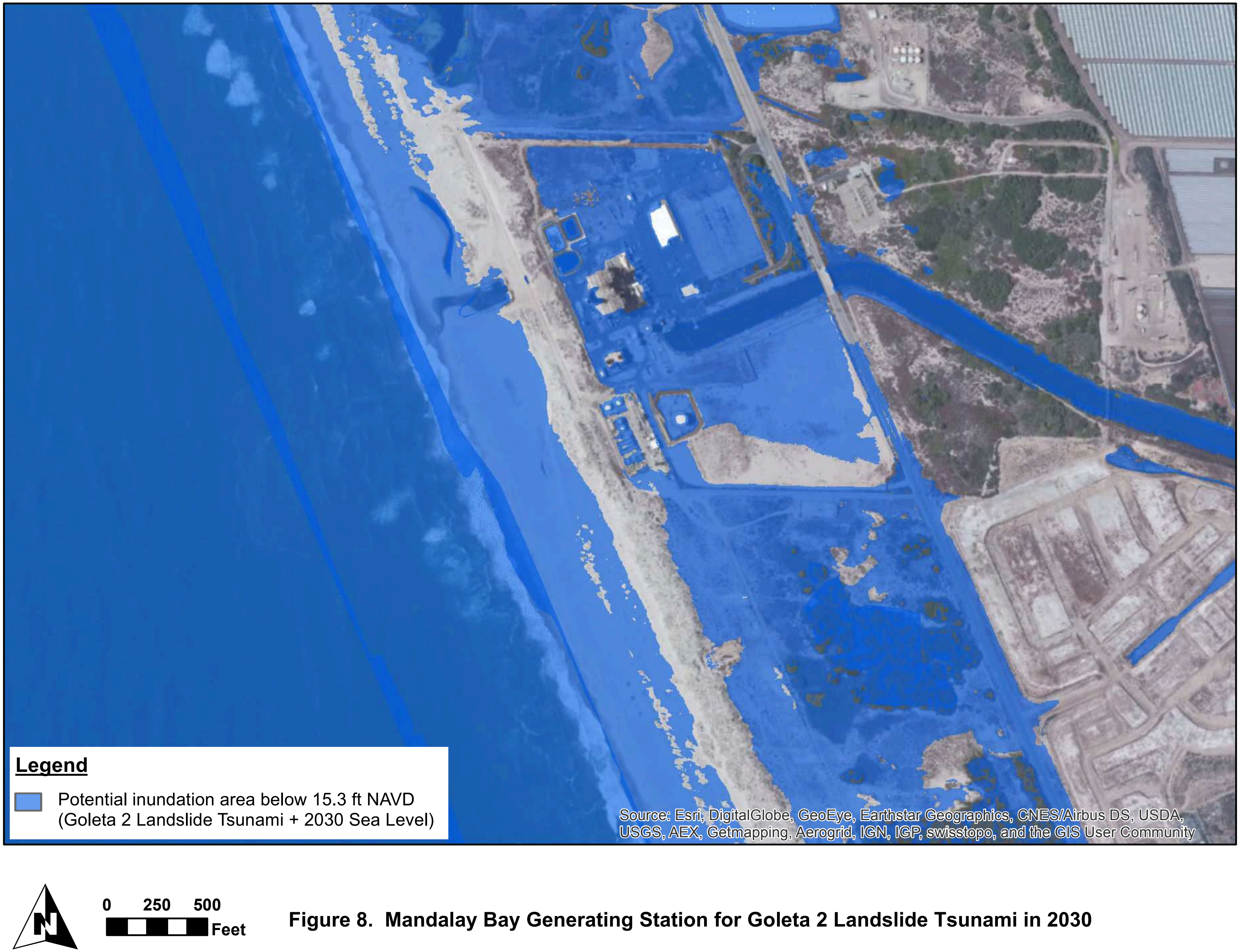


Figure 8. Mandalay Bay Generating Station for Goleta 2 Landslide Tsunami in 2030

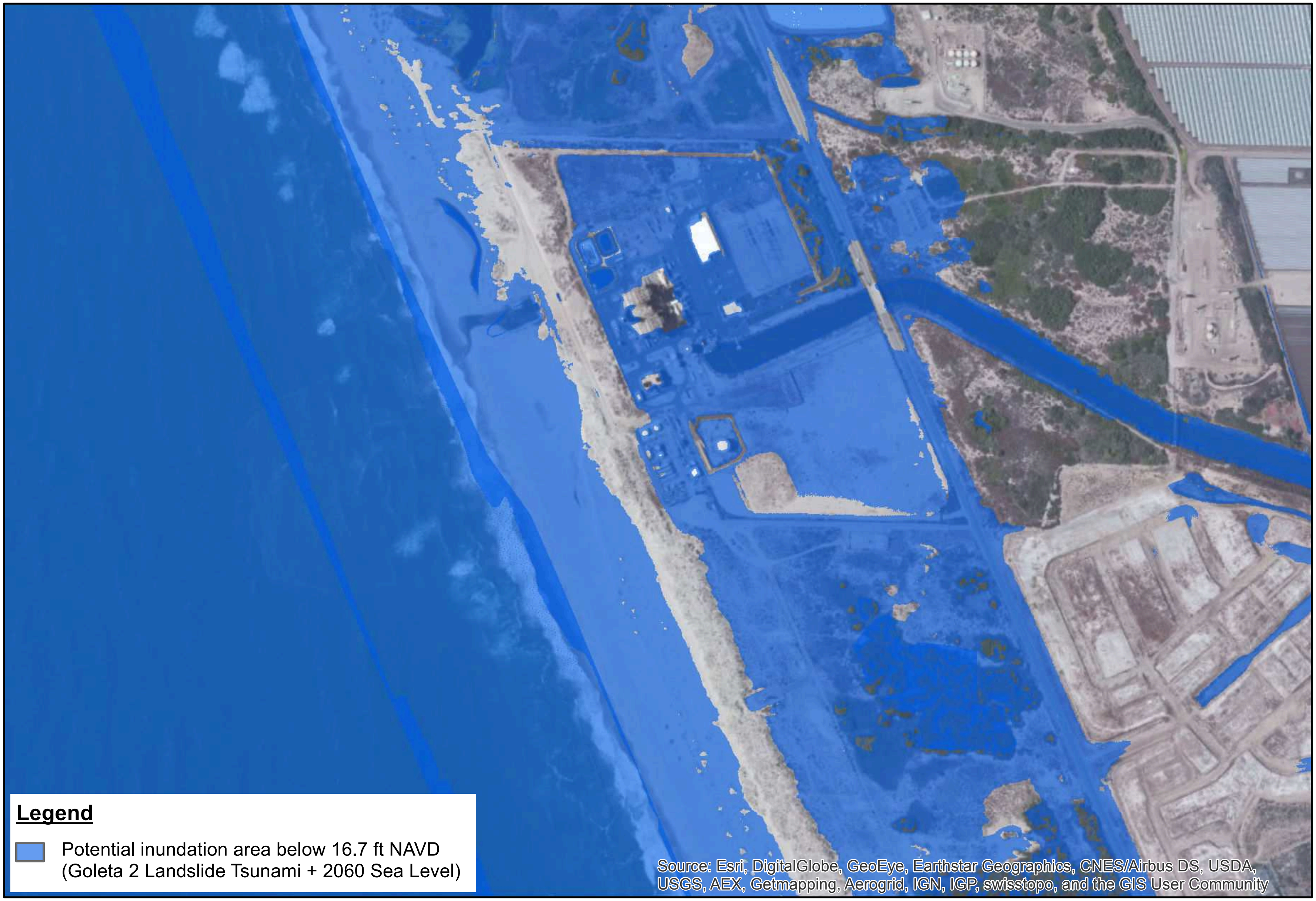


Figure 9. Mandalay Bay Generating Station for Goleta 2 Landslide Tsunami in 2060

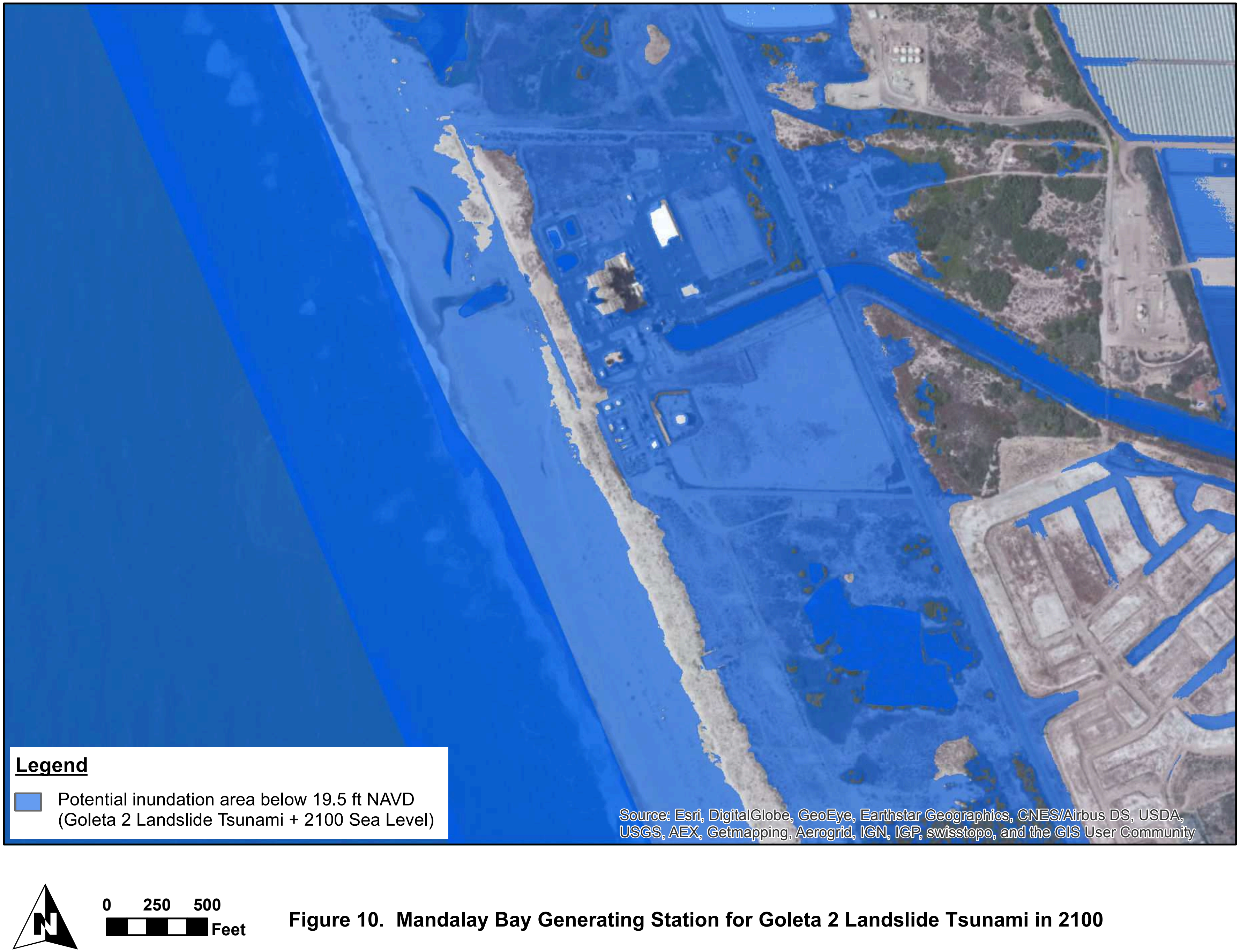


Figure 10. Mandalay Bay Generating Station for Goleta 2 Landslide Tsunami in 2100